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A 48-CHANNEL CARRIER TELEPHONE SYSTEM

II. MECHANICAL CONSTRUCTION

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For the expansion of the Netherlands inter-district telephone network that is now in hand the 48-channel carrier system developed by Philips in cooperation with the Dutch P.T.T. is being applied on a large scale. This system works with triple modulation. The form in which the system is being employed differs considerably from the usual construction. All the equipment belonging to one individual channel which is identical for all channels, is contained in one drawer; the respective components comprise 80% of the equipment for the whole system, excluding carrier feed and repeaters. Thus the installation contains 48 identical channel drawers. The rest of the apparatus is contained in two sets of four (smaller) group-repeater, drawers one group-combining drawer and one system-repeater drawer. The panels slide into racks and are connected to the rack wiring with the aid of socket blocks and four-pin plugs. In the case of a breakdown in one channel the defective drawer is removed and replaced by a spare one. This method of working and mechanical construction offers great advantages and has been made possible by drastic reduction in the volume (by a factor of 4 to 5) of all components compared with former installations; this is due for a large part to the application of the new magnetic material "Ferroxcube" for the cores of the filter coils. The result of the saving in space allows of the whole of the equipment (including signalling) for the 48-channel system being mounted on the front and back of only two racks.

In many countries the long-distance telephone networks are being considerably expanded, partly in order to catch up with the arrears in the normal expansion and partly also with a view to shortening the delay on long-distance calls, thus making better use of the advantages of full-automatic working.

In the Netherlands, too, the number of connections in the inter-district network is being considerably increased, inter alia by employing on a large scale the 48-channel carrier-telephone system developed by Philips in cooperation with the P.T.T.

As its name implies, with this system 48 calls modulated on carriers can be transmitted over one pair of conductors simultaneously. Of each call the audio-frequencies between 200 and 3400 c/s are transmitted in a channel having a width of 4 kc/s. The 48 channels together cover the frequency band from 12 to 204 kc/s. Thus full use is made of the

frequency range for which the Dutch carrier telephone cables are suitable, provided steps are taken according to the most recent ideas to prevent cross-talk between the pairs of conductors.

With this system a triple modulation system is used, the frequency allocations of which are indicated in *fig. 1*. For a detailed description of the method of modulation we refer to an article previously published in this journal ¹⁾. We shall only recapitulate here the main points. Each conversation to be transmitted is brought into a basic channel of 60-64 kc/s by means of a pre-modulator. The undesired modulation products, in particular the lower side-band, are suppressed by a channel band filter, which is identical for all the 48 basic channels. In the next stage each twelve of these basic channels are modulated with

¹⁾ G. H. Bast, D. Goedhart and J. F. Schouten, A 48-channel carrier telephone system, I, Choice of the method of modulation, Philips Techn. Rev. 9, 161-170, 1947 (No. 6).

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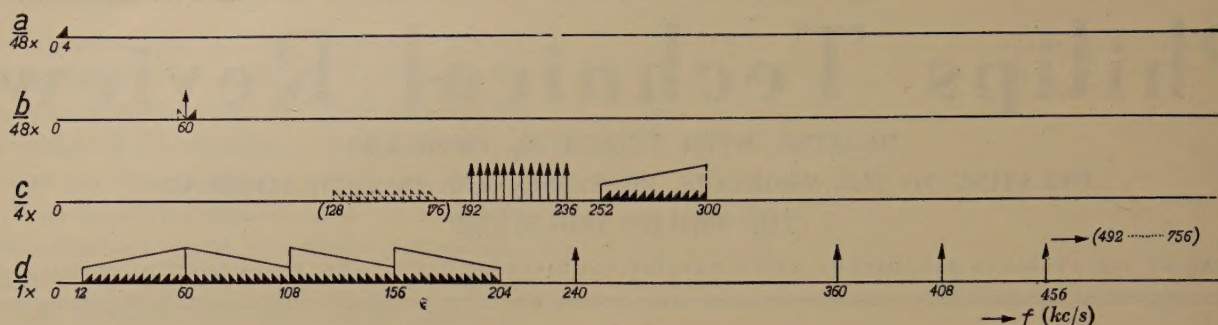


Fig. 1. Frequency allocation of the method of modulation of the 48-channel system. a) Low-frequency channel in the frequency range 0-4 kc/s. The ascending line indicates the rise of the audio-frequencies. b) Pre-modulation with 60 kc/s carrier. From each low-frequency channel a basic channel is formed lying in the frequency range 60-64 kc/s. The undesired lower side-band suppressed by the channel band filter is denoted by dotted lines. c) Second modulation with the 12 different carriers 192, 196, ... 236 kc/s for twelve basic channels. The result is a basic group in the frequency band 252-300 kc/s. d) Third modulation with the four carriers 240, 360, 408 and 456 kc/s for four basic groups. Thus the 48 channels are brought into their final position in the 12-204 kc/s band.

12 different carriers and combined into one basic group in the band 252-300 kc/s. Owing to the high frequency of the basic channel all undesired modulation products fall outside this band and can therefore be suppressed by a common group band filter. Finally, in the third modulation stage by means of four carriers the four basic groups are assembled to form a super-group lying in the band 12-204 kc/s. The undesired side-bands are here again suppressed by a common super-group filter, which owing to the wide separation of sidebands can be very simple.

The demodulation of the incoming calls takes place in three entirely analogous modulation stages.

The apparatus for the 48 channel-system is represented in fig. 2 in a block diagram (for one direction only; an identical apparatus is required in the opposite direction of transmission).

In this article we shall go more fully into the construction of the apparatus for this 48-channel system. Both in its general set-up and in its detailed construction the form given to this system differs considerably from what has been usual so far in carrier-telephone installations.

The fact that the choice of the method of modulation and the mechanical construction of the apparatus have been dealt with in two separate articles does not mean that they are really two separate things. On the contrary, the choice of the method of modulation is governed in no small degree by the principles of the mechanical construction, as we hope will be made clear from what follows.

Principles underlying the mechanical construction

Without confining our ideas to any specific method of modulation we may say that for a

multi-channel carrier system a number of modulators, filters, amplifiers, etc. will be needed for each channel. In large terminal stations there are frequently a number of cables in various directions which in all may comprise several hundreds or may be even some thousands of channels. In such stations there are consequently an enormous number of components. This fact largely governs the form to be given to any carrier system. The mounting of such a large number of elements in a not excessively large space, the localizing of a defective element in the case of a breakdown, the surveying of the whole when carrying out the necessary maintenance tests, the provision of the necessary spare components, all constitute problems of the first order which have to be taken into account. The matter is still further complicated by the consideration that the station can never be regarded as being a definitive installation: it must always be possible to extend the number of connections or to alter their distribution in different directions without too much difficulty.

In the designing of the 48-channel system the primary aim was to arrive at a more rational and more economical solution of the aforementioned fundamental problems. An essential condition was to reduce the dimensions of the components as compared with former constructions. A drastic reduction of the transducers, accompanied by an improvement of their frequency characteristics, was made possible by employing the new magnetic material "Ferrocube" for the cores of the coils²⁾. This material has therefore played an important part in the development of the new system.

²⁾ G. L. Snoek, Non-metallic magnetic material for high frequencies, Philips Techn. Rev. 8, 353-360, 1946. See also the article quoted in footnote 1.

We shall now proceed to describe the general set-up of the apparatus for this system, with reference to an older type by way of comparison.

Distribution and mounting of the apparatus in racks

In many existing carrier systems the following method of construction is used. In the station there is a rack (possibly more than one) in which all the channel band filters and modulators are mounted, also racks with channel repeaters and racks with

For actual operation, however, such a construction has its disadvantages. It involves very extensive and complicated wiring, due to the fact that components of each channel are distributed among a number of racks. When carrying out the usual test measurements for the regular overhaul one has to check all these racks in succession for each channel. In the event of a breakdown in any one channel all the racks have to be checked to trace the defect, whilst to repair it all sorts of soldered

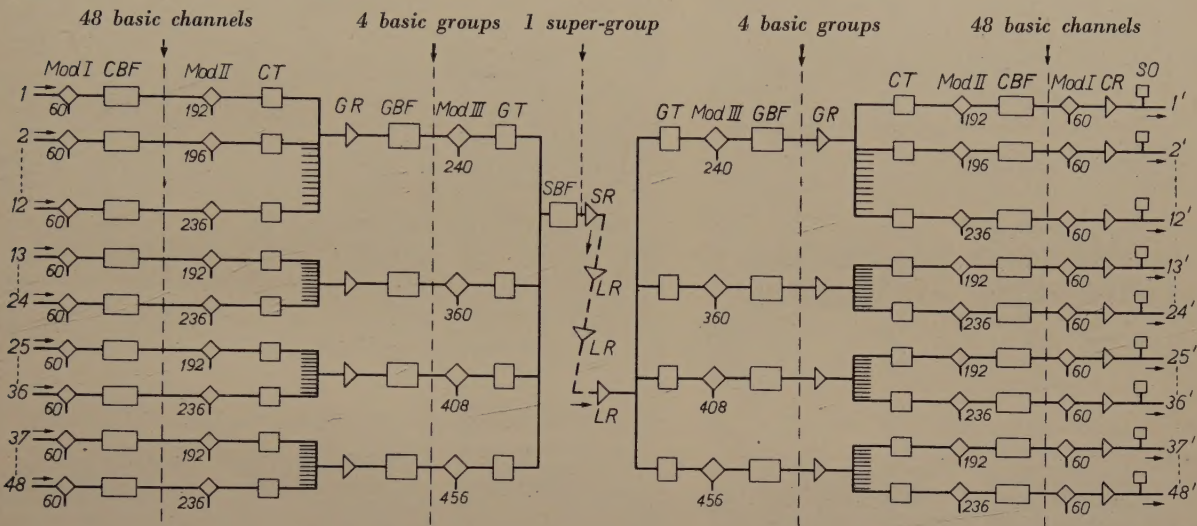


Fig. 2. Apparatus of the 48-channel system for one direction of transmission. The subscribers' lines at the transmitting end are numbered from 1 to 48 and those at the receiving end from 1' to 48'. *Mod I* is the pre-modulator, *CBF* a channel band filter, *Mod II* second modulator, *CT* channel transducer; *GR* group repeater, by means of which the audio signals of 12 bundled channels attenuated through modulation and filtering are again amplified sufficiently high above the noise level; *GBF* group band filter, *Mod III* third modulator, *GT* group transducer, *SBF* super-group band filter; *SR* system repeater raising all 48 channels to the level desired for transmission along the cable. *LR* line repeaters connected to the cable at distances of 25 km, the last repeater being in the terminal station itself. At the receiving end in each channel there is a channel repeater *CR*, which compensates the attenuation by the last stages of the demodulation, and the signal receiver *SO*, which deals with the signals for dialling, etc.

signal receivers, etc. These elements are mounted on panels and a series of such panels are fixed onto a rack one above the other; see fig. 3. The leads of each apparatus are soldered to terminals grouped together on a block for each panel. On the other side of the terminal blocks are the soldered wire connections between the panels and between the racks.

This may in a certain sense be regarded as a surveyable or at least a systematic construction, and it was considered an advantage that the transducers and modulators, which as regards their properties are the most sensitive to temperature changes, are kept apart from the elements containing sources of heat (repeater valves, supply transformers).

connections have to be loosened and then resoldered. The complicated wiring, and in particular the numerous soldered connections, make it difficult to expand or alter the systems in a station. The large number of soldered connections was also awkward for the manufacturers: the desire to minimize the amount of soldering work to be done in the station itself meant that the factory had to deliver a rack complete with all its apparatus already mounted, and considering the heavy weight of the completely mounted racks this involved many difficulties.

Let us compare with this the fundamentals of the construction of the new 48-channel system. Two racks of this system are illustrated in fig. 4. Owing to the method of modulation by far the greater part of the apparatus is identical for all channels. All

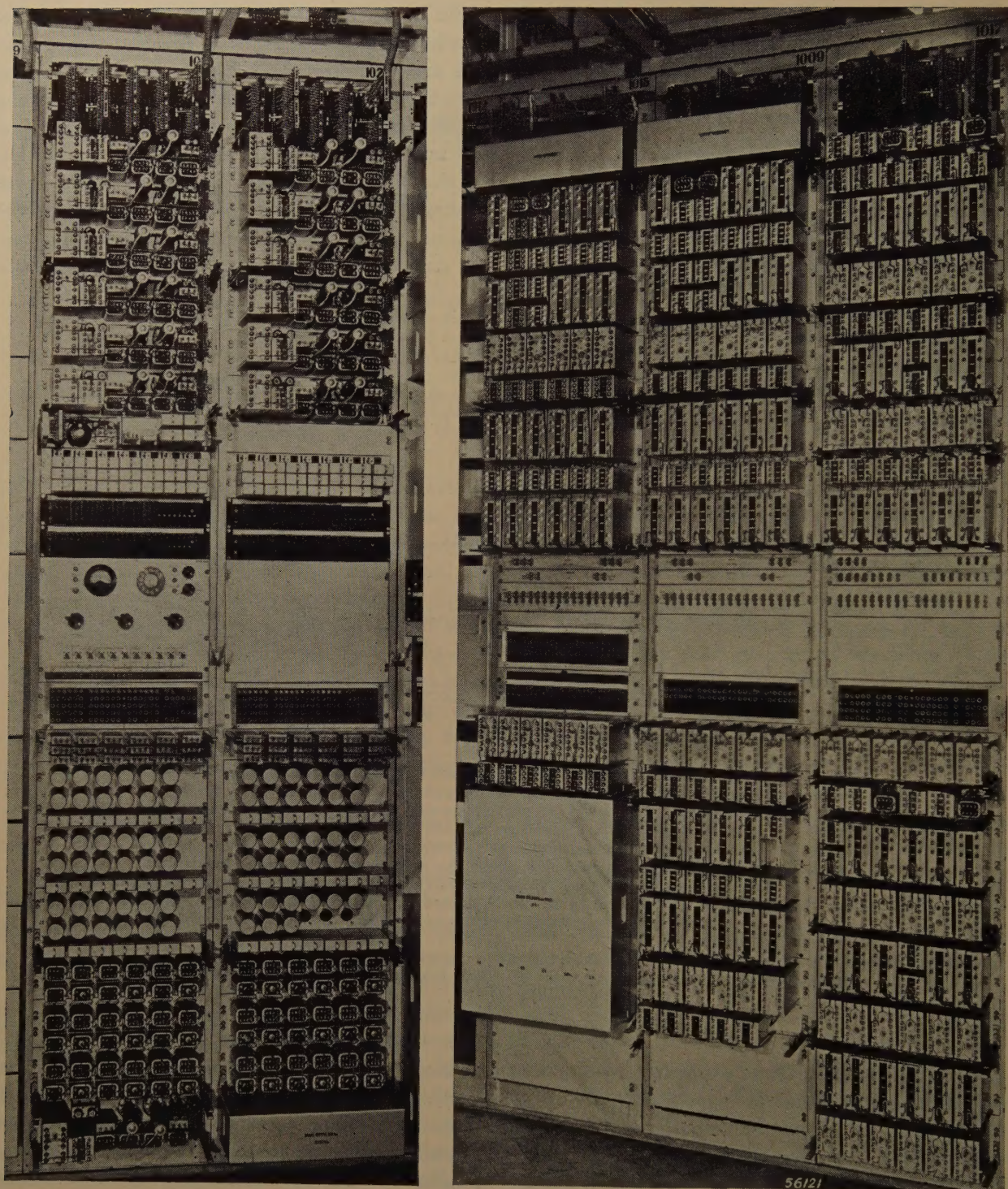


Fig. 3. Part of a carrier telephone equipment (Philips 17-channel system) built in a manner that has been customary in the past. On the right, racks with filters and modulators (the covers of most of the panels have been removed); on the left racks with signal receivers (at the top) and relays and transformers (at the bottom).

components that are identical are assembled for each channel and housed in a drawer, both those for transmission and those for reception. Thus in the 48-channel system we have 48 absolutely identical channel drawers containing the major part (about 80%) of the equipment: in each drawer there are

mounted, among others, a pre-modulator, a channel band filter and a second modulator for the transmission path, together with the same elements for the reception path and, moreover, a channel repeater (including attenuation equalizer) and a signal receiver. The racks are built in the form of open

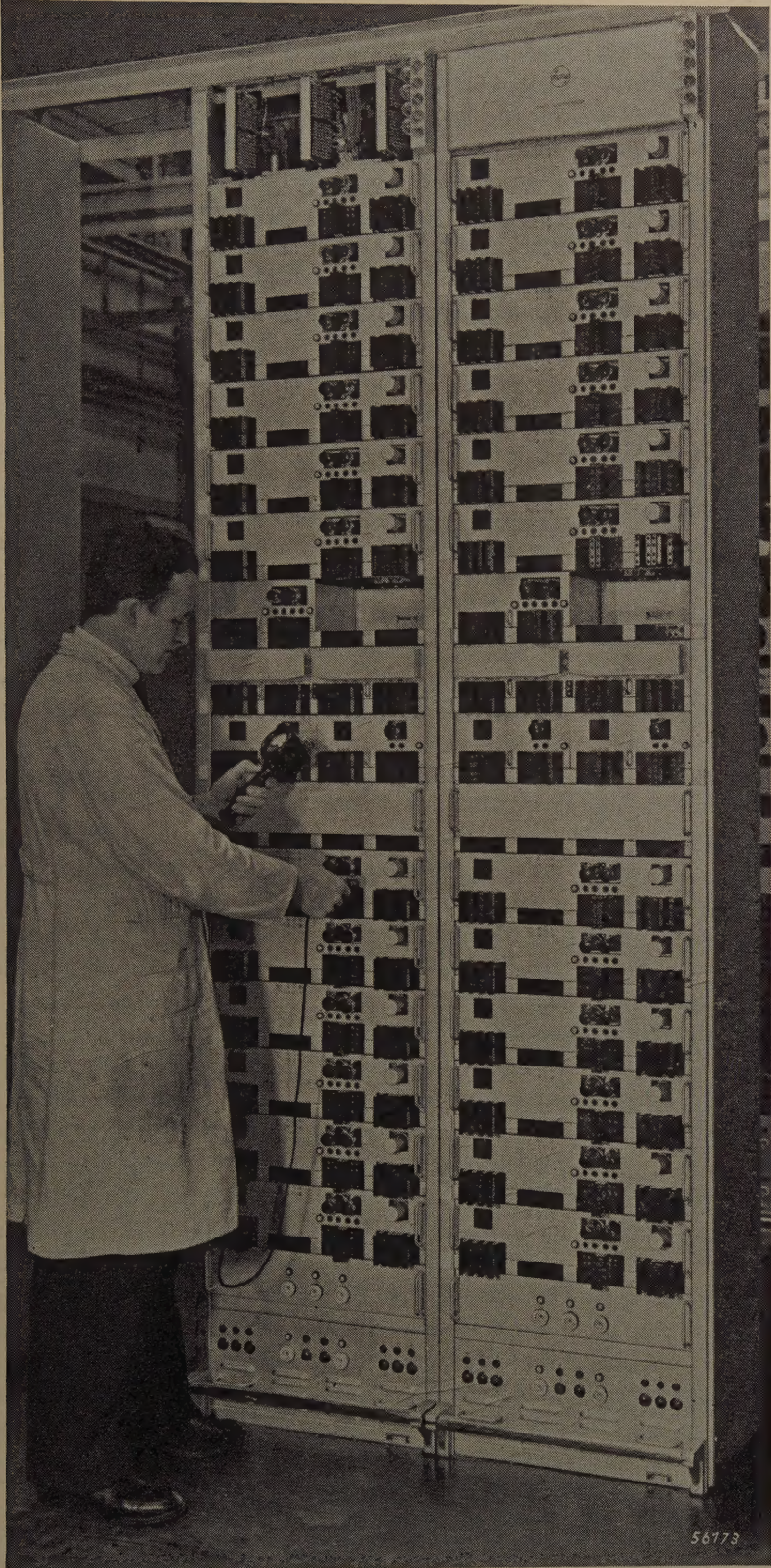


Fig. 4

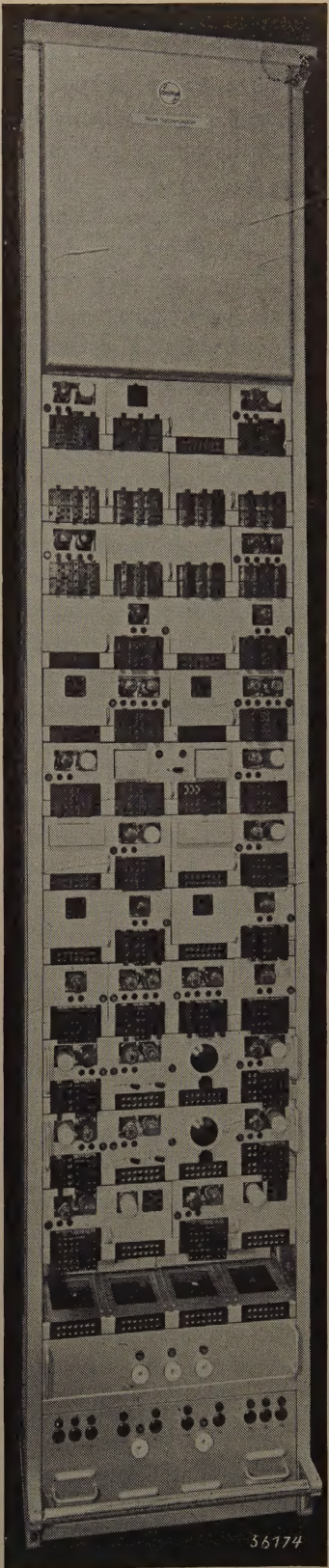


Fig. 5

Fig. 4. Racks of the 48-channel system. The apparatus is contained in sliding drawers. All components belonging to one channel which are identical for all channels, are mounted in one drawer. Thus the system has 48 identical channel drawers containing 80% of the whole equipment. Further there are eight group-amplifying drawers, a group-combining drawer, a system-repeater drawer, spare drawers and drawers with sundry accessories. The complete apparatus of a 48-channel system (excluding the carrier supply) is contained on the front and back of the two "system racks" shown here.

Fig. 5. Carrier supply rack of the 48-channel system. With the apparatus on the front and back of this rack 6×48 channels can be supplied.

cabinets with shelves between which the drawers can be pushed in from the front and back. Socket blocks form the terminals for the wiring of the drawer and come to lie in line with corresponding blocks on the rack shelves, to which blocks the rack wiring is connected. The drawer is connected up by a set of four-pin plugs. On one side of the rack there is room for 12 channel drawers. Further there is room for two drawers containing the apparatus, separated for transmission and reception, for filtering out and amplifying a basic group; for a drawer making up one super-group from four basic groups; and further for other various drawers.

The manner in which the apparatus is combined simplifies the wiring of the racks. For the overhauling of a channel all measuring points are found to lie close together. In the case of a breakdown of a channel there is no need first to trace the defect in the corresponding drawer (a signal lamp shows which drawer is out of order) but one simply removes the whole drawer, after taking out the connecting plugs, and replaces it by a spare. Since all the channel drawers are identical, in principle only one spare drawer has to be kept in reserve for the whole system of 48 channels and there is no risk of a mistake being made in the replacement. The defective drawer can then be taken to a workshop for examination and repair. A similar procedure is followed also for other parts of the apparatus, for instance the mutually identical group-repeater drawers, so that ideal conditions for the organisation of telephone services are very well approximated: in the stations themselves there is nothing else to be done than to replace components, repairs being carried out by specially trained workmen in a workshop which can serve several stations.

Such a method of construction as described here obviously has its advantages also for the manufacturer. All the channel drawers being identical, they can be built in large series. Racks and drawers are built up complete in the factory and can be transported to the repeater station in separate units. Of course the cables between the racks have to be connected in the station itself after the empty racks have been set up in position, and once this has been done there is no need for any further soldering. Then the drawers only need to be placed in the racks and connected up with plugs, the installation then being ready for the final check-over before being put into operation. One might compare it to the erection of pre-fabricated houses and ships ³⁾.

Presently we shall go into the construction of the drawers and their parts in more detail, but before

doing so we have something to say about the importance of the reduction in size of all the components. It was only because all the equipment for an individual channel could be made sufficiently small, and of light weight to be handled easily by one man, that the principle of sliding channel drawers became a practicable proposition. Moreover, this was in itself of course highly important with a view to limiting the dimensions of the station as a whole: the complete apparatus of this 48-channel system is now contained in no more than two racks, as compared with 8 or 10 in former equivalent systems.

The principle of building racks of telephone installations in the form of sets of drawers and mounting the apparatus in sliding drawers with socket blocks was already applied by the Dutch P.T.T. about 1936 for the line repeaters of the low-frequency telephone networks. These repeaters formed natural units of not too large a volume. It was then applied mainly because of the advantages offered for easy expansion: starting for instance with 40 repeaters per rack, the installations could be expanded as required up to a maximum of 100 repeaters per rack simply by adding more repeater drawers.

In addition to the apparatus of the system proper, the installation of the station comprises a carrier supply apparatus and the line repeaters with attenuation equalizers for the incoming carrier cables. These parts are mounted on separate racks, the carrier supply for six 48-channel systems occupying only one rack. In *fig. 5* a photograph is reproduced of a carrier supply rack, details of which we shall not go into in this article.

We shall conclude this general review by drawing attention to the fact that on each side of the rack there is a complete basic group of 12 channels, which can be dealt with as an independent group. This means that it is possible to start with a 12-channel system, for instance when there is not much traffic along a cable, and to extend it as the traffic increases by adding further groups to build up a 24-, 36- or 48-channel system (provided of course that the cable itself and the line repeaters are calculated to take that number). It is also possible, for instance, to split up an existing 48-channel system into two equal halves of two groups each

³⁾ The first installation according to the system described (with 24 instead of 48 channels) was supplied by Philips in October 1947 for the station at Chur in Switzerland, where the number of connections had to be extended at short notice for the 1948 Olympic Winter Games. This was a striking example of how delivery can be expedited owing to the easier transportation (in this particular case all the drawers were transported by plane) and the fact that the racks in the station can already be connected up before the drawers arrive.

(24 channels) and to conduct the calls from the two halves to two different cables. Thus, compared with former systems, this installation is much more flexible.

Details of equipment

In fig. 2 a block diagram has been given of the major components of the apparatus for the 48-channel system. In fig. 6 it is now shown in more detail how the equipment is distributed in drawers. With the aid of this diagram we can explain some details of this distribution.

As already stated, in each channel drawer there is, among others, the pre-modulator, the channel band filter and the second modulator, for the transmission and receiving paths; see the part *I* framed in fig. 6. The second modulator is, it is true, fed with a different carrier frequency for each of the 12 channels of a group, but these frequencies come from the rack wiring, there being no difference in the modulators themselves. Thus the drawers are identical, only the position of the drawer in the rack determining which of the 12 bands between 252 and 300 kc/s will appear at the output of the drawer.

The channel transducers (*CT*) on the other hand do indeed differ for the 12 channels. Therefore, in order to keep the channel drawers identical, these filters are not mounted in the channel drawer, each of the twelve pairs of different filters being fitted in the corresponding shelf of the rack. This does not involve any great complication in the manufacture, since the coupling filters are extremely simple (see the article referred to in footnote ¹)).

A repeater and group band filter constitute the main components of each group-repeater drawer. These drawers, for transmitting and receiving ends, are likewise framed in fig. 6 (parts *IIa* and *IIb* respectively).

Then there are the four group modulators with group transducers (*GT*) contained in a group-combining drawer (the framed part *III* in fig. 6) for the transmitting and receiving ends together. Each basic group can be connected to each of the four modulators, so that if desired, by adding a second group-combining drawer — in the normal 48-channel system there is only one —, the system can be split up for instance into two 24-channel systems in the same frequency range, e.g. in the

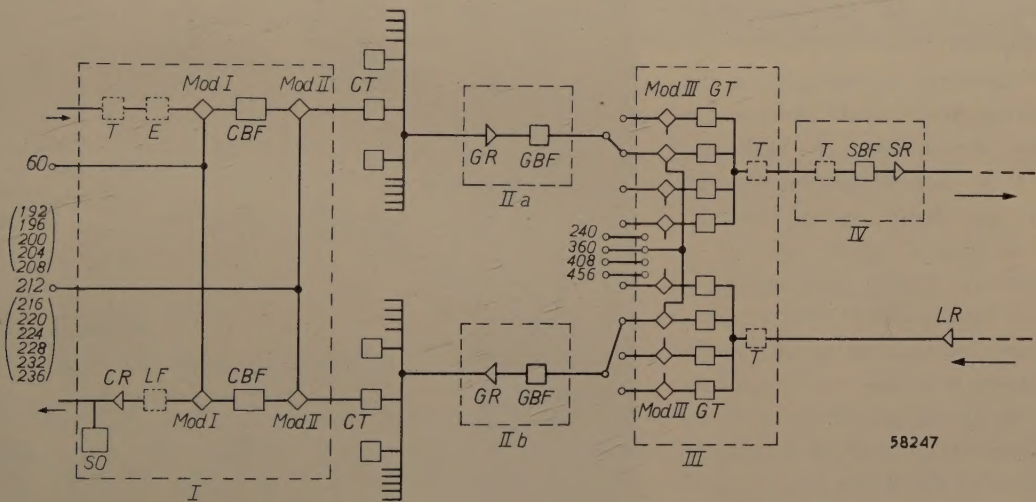


Fig. 6. The combining of the equipment of the 48-channel system in drawers. There are 48 identical drawers *I*, each containing practically the whole of the equipment of an individual channel both for transmitting and for receiving. This has been made possible owing to the apparatus being identical for all channels, due to the method of modulation chosen. Only the channel transducers *CT* differ for the 12 channels of the group and they are therefore not contained in the channel drawers *I* but in the rack shelves on which the drawers are placed. Further, there are four identical group-repeater drawers *IIa* for transmitting and four similar drawers *IIb* for receiving, one group-combining drawer *III* and one system-repeater drawer *IV*. The meaning of the letters is as given under fig. 2. Some less essential elements which were left out in fig. 2 are indicated here in dotted lines: *E* equalizer, *T* transformers for matching or separation, *LF* low-pass filter for suppressing what is left of any carrier leaking through from the adjacent channel (which would be audible as a whistling note of 4000 c/s).

In some installations it may not be desired to consider the signal receiver acting as the last element on the reception side as belonging to the carrier-apparatus. This applies to stations where signal receivers are already installed for all outgoing telephone lines. For such cases as this a somewhat different type of channel drawer is made without signal receiver; an example of this is the Swiss installation mentioned in footnote 3.

frequency band 12-108 kc/s. On the side of the rack where there is no group-combining drawer another drawer can be inserted containing measuring apparatus or suchlike. Finally, in the 48-channel system there is one drawer containing the super-group filter and the system repeater (the part *IV* framed in fig. 6). The super-group filter is not a band filter but can be a simple low-pass filter, as may be readily understood from an examination of the modulation system in fig. 1.

Right at the bottom of each rack is the alarm apparatus and the power supply, i.e. the filament transformers; the anode voltages are supplied by the storage batteries installed in every terminal station. At the top of the rack are the terminal blocks for connecting up the inter-rack cables. The wiring of the rack itself is contained in the side walls of the rack and in the shelves between the drawers. The wiring in the open sides of the outermost racks in a row is screened off by covering plates.

All the terminal connections on the socket blocks fitted on the shelves for the channel drawers are in duplicate, so that test measurements can be taken or an aged valve can be replaced without interrupting a conversation taking place along a channel in the corresponding drawer; this is done by connecting the spare channel drawer to the corresponding shelf by means of patching cords, so that this can take over temporarily the function of the operating channel drawer. In order to facilitate this connection with patching cords to all channels the spare drawer is placed in the middle of the rack. For normal service measurements on drawers the connecting plugs are used as measuring points.

Fig. 7 shows how the channel drawer with a spare drawer, two group-repeater drawers, a group-combining drawer and the system-repeater drawer are arranged on one side of the rack. This photograph also shows some of the details

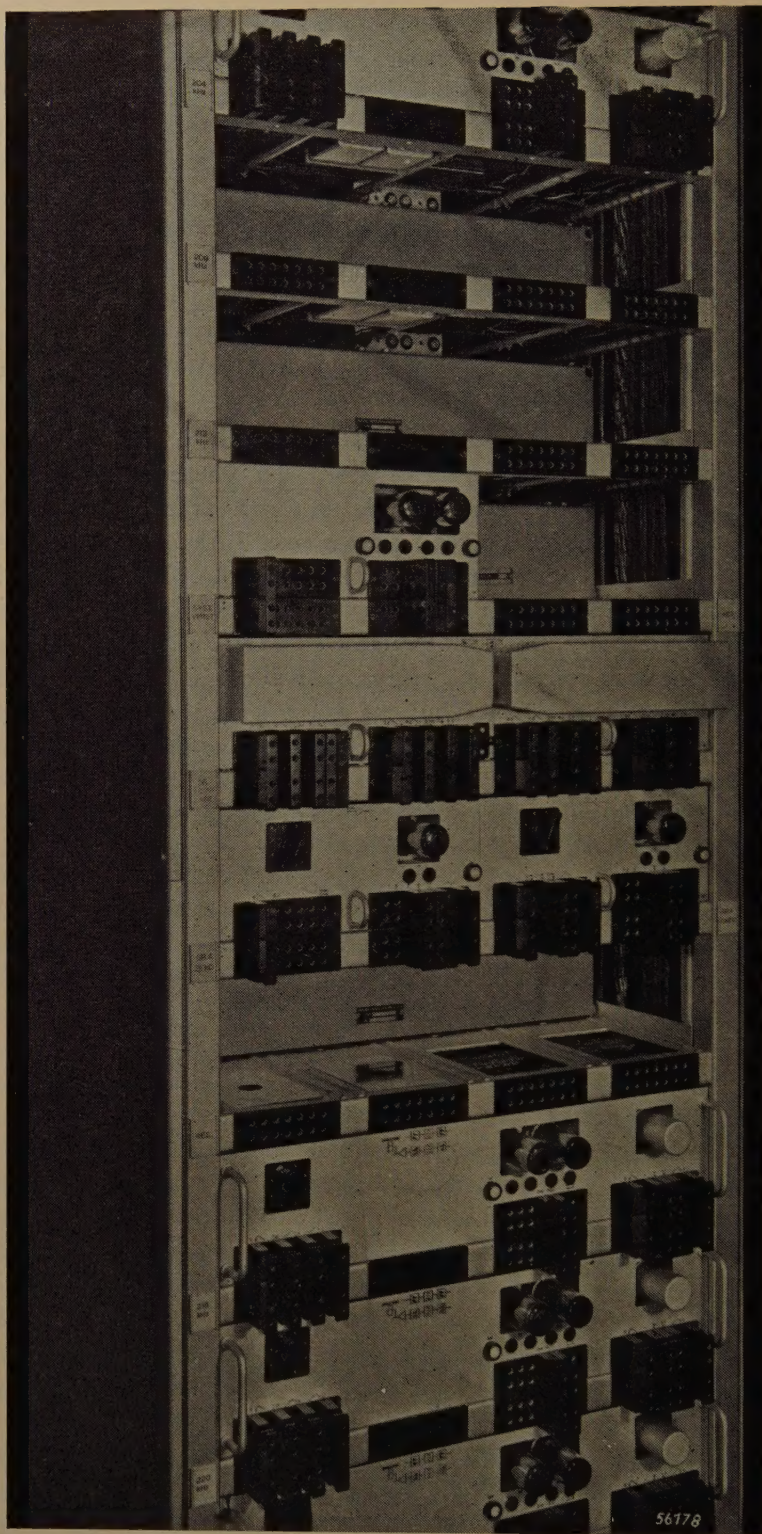


Fig. 7. Close-up of a system rack of the 48-channel system. The compartment for the spare channel drawer (in the middle) and a half compartment for a spare system-repeater drawer have been left open; higher up two channel drawers have been taken out to show the wiring in the shelves and in the side walls of this rack. In the shelves may also be seen the small cans containing the channel transducers. The connection between the rack wiring and the drawers is made by means of sets of four-pin plugs fitting into the socket blocks.

mentioned above, such as the placing of the channel transducers, the wiring, etc.

Construction of drawers and components

This distribution of the components in drawers allows not only of a splitting up of the equipment into natural units but also of standardization of the dimensions of the drawers. In the racks there are only two types of drawers, whole and half ones; in the carrier-feeding rack, which we are

necessary. The photograph of a channel drawer in *fig. 8* clearly shows this "two-dimensional" wiring and the compact arrangement of the components in the drawer.

The cans are not filled up with a compound, as they used to be, but are sealed by soldering. This results in a great saving in weight, so essential for

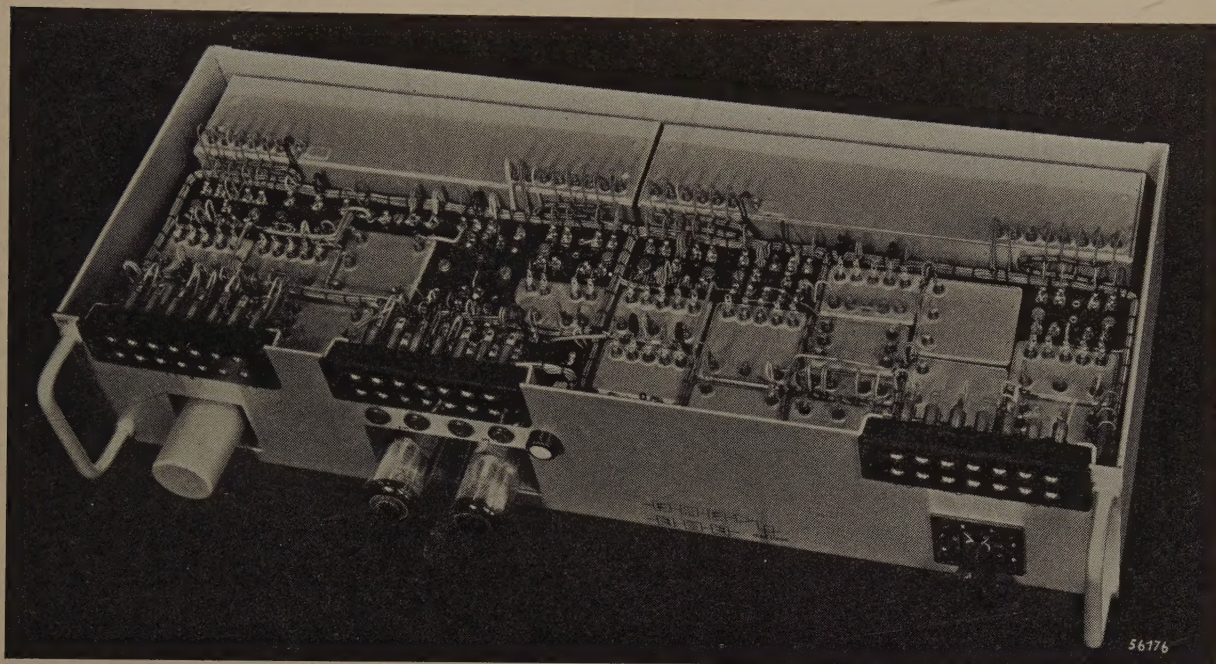


Fig. 8. Channel drawer ready to be put into the rack. The channel band filters for the transmitting and receiving ends are contained in two long cans, which are slightly higher than the others and occupy the rearmost part of the drawer. All other components (e.g. modulators, transformers, equalizers, condensers, etc.) are contained in cans all of the same height and width and with standardized depths. In this way all the space available in the drawer is filled up compactly and the wiring is kept flat. The repeater valves (one for the channel repeater and one for the signal receiver) protrude, so that they can easily be replaced and do not cause undesired heating of the components in the drawer. In the middle of the front plate of the drawer is a signal lamp which lights up in the event of a defect arising in the drawer. By means of a control knob on the right-hand side of the front panel (on the left if the drawer is placed in the rack upside down) the gain of the channel repeater can be adjusted to the right value while the drawer is being tested.

not dealing with here, there are also quarter drawers. This standardization is of importance for the manufacture of the installation and obviously allows of the space available in the rack being fully utilized.

Of course also the space inside each drawer has to be utilized to the best advantage. To this end the dimensions of the cans in which most parts, such as filters, transformers, etc., are contained are likewise standardized. Except those contained in the band filters all cans are of the same height and width, though there are four different depths. Thanks to this uniformity of height the wiring inside the drawer can be kept entirely in one plane, making it easily surveyable and facilitating not only the wiring up in the factory but also repairs where

sliding out the drawers, whilst there is still sufficient protection against the influence of moisture on the insulating material and dielectrics in the components. Each can has two pins underneath fitting into holes in the bottom of the drawer and secured with nuts. The drawers are put in the racks upside down so that no dust can settle in them. The repeater valves, of which there are for instance two in each channel drawer — one for the channel repeater and one for the signal receiver —, protrude at the front of the drawer; this facilitates replacement and, moreover, contributes towards an adequate heat transfer. This also avoided the previously mentioned point about inadvisability of the modulators being mounted on one rack together with the heat-spreading valves. Nevertheless the filters

and modulators are placed as far away as possible from the valves by mounting them right in the back of the channel drawer; this precaution has proved to be quite satisfactory, the influence of the conduction of heat to the filters being imperceptible.

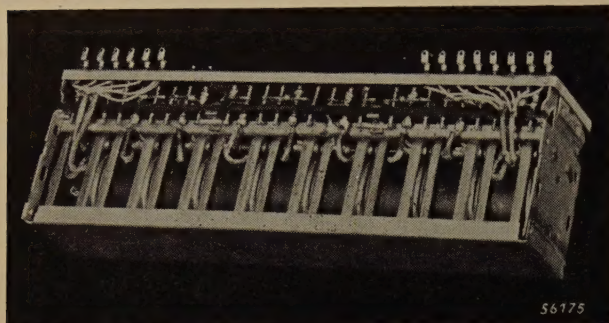


Fig. 9. Channel band filter, opened. The coils (at the bottom) and the condensers (at the top) are arranged in the same order as is usually followed when drawing the circuit diagram of such a filter (see fig. 9 of the article quoted in footnote ¹). Owing to the high permeability of the "Ferroxcube" cores, the coils can be placed side by side without screening.

The internal construction of the channel band filter is shown in fig. 9.

The very considerable reduction in the size of the parts, to which reference has been made several times already, is illustrated in fig. 10. There we see

equipment. But also the other parts have been drastically reduced in volume. In the case of the modulators this has been achieved by an artifice. Each modulator contains four small selenium rectifiers, an input transformer and an output transformer. Since however, as shown in fig. 6, there is a filter adjoining one side of each modulator, the transformer on that side could be dispensed with by making an extra winding on the core of the first (or last) filter coil and letting the coil itself function as the other winding of the transformer.

The reduction reached in the size of the cans, compared with the former normal dimensions, would have been incomplete if it had not proved possible at the same time to reduce the seals of the cans considerably. Fig. 10 shows the comparatively long ceramic seals of the old cans, which have now been replaced by a construction with a glass bead tinned round the circumference and soldered into an opening in the top of the can. The sealing beads of all the cans in a drawer come to lie in one continuous rectangular pattern, thereby giving the flat wiring the aspect of compactness as seen in fig. 8.

Finally it is to be mentioned that only one type of repeater valve is used in the installation. This valve, a pentode (type 18040), has been specially designed

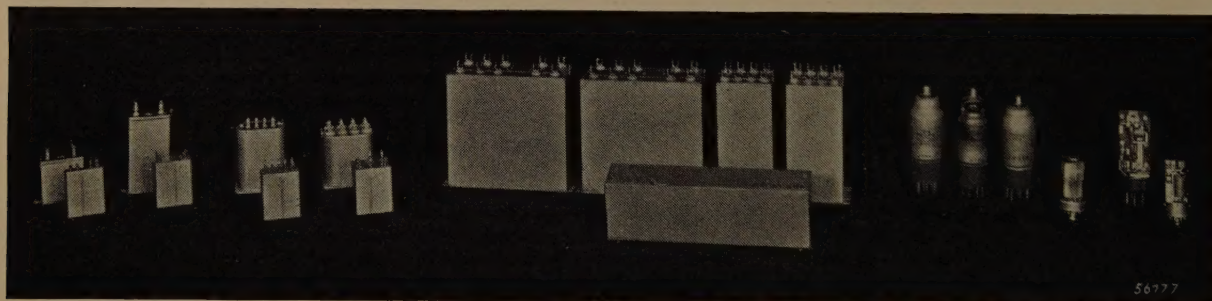


Fig. 10. Comparison of components of the 17-channel system (placed at the back) with those of the new 48-channel system (in the front). From left to right: two condensers, two transformers, a channel band filter (in the old system consisting of four boxes), the repeater valves and a relay. The reduction of the dimensions in the new system and the standardization of the parts are clearly seen: the two condensers and transformers are now in cans of the same width and height; only in the depth are there four different dimensions. Whereas formerly three types of valves were used, viz. types 18013, 18014 and 18015, now there is only one type, 18040.

a channel band filter compared with the corresponding filter of an older system (the Philips 17-channel system ⁴). This reduction in size, made possible by employing "Ferroxcube", will be realized when one considers that the channel filters in earlier systems often represented about half of the channel

for the desired universal application. Moreover, being built according to the C-technique (all-glass envelope with flat base), it is of much smaller dimensions than the valves formerly employed in telephone installations; see fig. 10. Thus here again the principles of reduction and standardization have been applied, such as characterize the construction of the whole of the 48-channel system.

⁴) See Th. J. Weijers, Filters for carrier-wave telephony installations, Philips Techn. Rev. 7. 104-112, 1942.

CELLULOSE FIBRE

PHOTOGRAPH TAKEN WITH THE PHILIPS ELECTRON MICROSCOPE EM 100



This is a fibre of a special kind of paper used, inter alia, as dielectric for high-tension capacitors. The photograph clearly shows that the fibre (which happens to be narrower than normal specimens) is in itself of a fibrous structure with fibrils about $80\text{ m}\mu$ in width.

The magnification is comparatively small (6000 times) but the resolving power is remarkably high. The large field of vision at such small magnifications is a characteristic feature of the EM 100.

Before being placed in the microscope the specimen was "shadowed" in a well-known manner to bring it out clearly in relief: it was exposed in vacuum to a directed beam of vaporized gold. The electrons are strongly scattered by atoms of gold, so that the picture shows less blackening of the parts where gold has been precipitated, whereas the parts of the specimen lying in the "shadow" when the beam of gold was directed upon it, received no gold and thus show up in the picture as real deep black shadows.

PROJECTION-TELEVISION RECEIVER

V. THE SYNCHRONISATION

by J. HAANTJES and F. KERKHOF.

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The video signal sent out by a television transmitter contains both picture and synchronisation signals, of which latter there are two kinds, one for the horizontal and one for the vertical scanning. In previous articles it has been shown how in a receiver the synchronisation signals are separated from the picture signal and how the two kinds of synchronising signals are separated one from the other by means of two *R-C* circuits. As regards the vertical synchronisation this method is not accurate because the moment at which the voltage on the corresponding capacitor passes a threshold value is not sharply defined, and this may lead to a troublesome "pairing" of the lines forming the television picture. Here a circuit is described which is free of this evil. In this system a resistor is again used in series with a capacitor, but it is from the resistor that the voltage is taken. At a certain point in the vertical synchronising signal this voltage shows a peak with a steep front. This peak synchronises the saw-tooth generator for the vertical deflection. — The number of valves can be minimized by using two heptode-triode valves (ECH 21), the triode system of which forms part of the saw-tooth generator for the horizontal and vertical deflections respectively. The method described is suitable for all present-day television standards.

The series of articles on the Philips projection television receiver is now concluded with a description of the manner in which the synchronisation of the horizontal and vertical deflections is achieved in this set.

In the previous article ¹⁾ mention was made of the two blocking oscillators each supplying a saw-tooth voltage for controlling an output stage. The output stages produce saw-tooth currents which flow through the deflection coils and thus periodically deflect the electron beam in the cathode-ray tube in the horizontal and in the vertical direction. This deflection must of course be accurately in phase with the movement of the electron beam scanning the picture in the transmitter. To ensure synchronism, in addition to the picture signal synchronising signals are transmitted which, by means of certain circuits which will be described later, introduce a current pulse just at the right moment in the triode of each of the saw-tooth oscillators.

All the characteristic data of a television transmitter — the form of modulation (positive or negative, see below), the form of the synchronising signals, the manner of scanning (interlaced or not), the number of lines per picture, the number of pictures per second and other data of a similar nature — are collectively referred to as the tele-

vision standard. So far there is very little international uniformity in regard to television standards; most closely approximating each other are the British and French standards, which differ only in the number of lines per picture and in a few details of the synchronising signals. We shall deal here briefly with two of the points mentioned, the form of the modulation and the synchronising signals.

Positive and negative modulation; the two kinds of synchronising signals

In Great Britain and France "positive (amplitude-) modulation" is used, that is to say the greatest brightness in the picture to be transmitted corresponds to the maximum carrier-wave amplitude (100%) whilst zero brightness corresponds to a given lower amplitude (black level) lying for instance at 30%. The synchronising signals consist of a variation of the carrier amplitude between this black level and zero according to rectangular pulses ²⁾.

In the U.S.A. on the other hand "negative (amplitude-) modulation" is usually employed, the maximum picture brightness corresponding to the zero carrier amplitude and the black level lying at, for instance, 75% of the maximum amplitude, whilst the synchronising signals are formed by block-shaped pulses between the black level and 100%. The experimental transmitter at Eindhoven

¹⁾ Projection-television receiver, IV. The circuits for deflecting the electron beam, by J. Haantjes and F. Kerkhof, Philips Techn. Rev. 10, 307-317, 1949 (No. 10). This article will further be referred to here as article IV.

²⁾ See, for instance, the article on television receivers, Philips Techn. Rev. 4, 342-350, 1939.

(Netherlands) likewise works with negative modulation.

It is not the place here to weigh up the advantages and disadvantages of the two systems, but it is to be remarked that for the synchronisation system to be described here it makes no difference whether positive or negative modulation is employed.

There are two kinds of synchronising signals to be distinguished, those for the synchronisation of the lines (horizontal deflection of the electron beam in the cathode-ray tube) and those for the synchronisation of the frames (vertical deflection).

Line synchronisation takes place after the tracing of each line; the moment at which a line has to begin is determined by the carrier amplitude being made zero (in the case of positive modulation) or 100% (in the case of negative modulation) for a certain time interval once per line; see *fig. 1a*. Apart from certain details, this applies for all television standards.

The signals for the vertical synchronisation differ rather more, but there is international uniformity in so far that after each frame during an interval of at least $10 T$ no picture signals are transmitted (thus at least 10 lines per frame or at least 20 lines per complete picture are lost), during which interval the video signal alternates in a rectangular manner in an alternating rhythm, partly at twice the line frequency and partly at the line frequency itself. By way of example, *figs 1b and c* give the form of the signal for vertical synchronisation according to the British and French standards ⁴⁾.

Separation of the signals

In *fig. 2* the block diagram of the synchronisation and deflection apparatus (the deflection apparatus was discussed in article IV) is given once again.

⁴⁾ Fig. 1 of the article quoted in footnote ²⁾ represents the form of the synchronising signals that were used at the time (1939) by the B.B.C.; they differ somewhat from the present form.

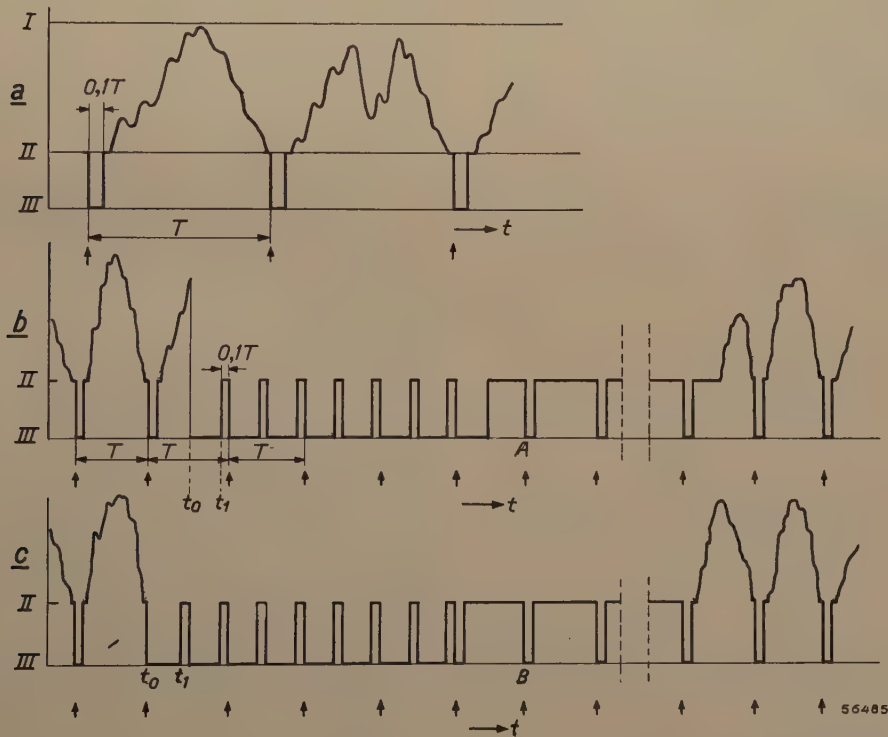


Fig. 1. Form of the video signal. *a*) The picture signal of a few lines with the line-synchronising pulses in between. *I* = level of greatest brightness, *II* = black level, *III* = level of the peaks of the synchronising signals. With positive modulation *I* corresponds to a modulation depth 100%, *II* corresponds to 30% and *III* to 0; with negative modulation *I* corresponds to 0, *II* to 75%, *III* to 100%. T = line period. — On another scale of the time t the signals for the vertical synchronisation to the British and French standards are represented under *b*) and *c*), this being what precedes an even and an odd frame respectively ³⁾, t_1 indicating the instant at which the vertical synchronisation takes place with the new system. The vertical arrows indicate the instants of horizontal synchronisation (line-synchronisation).

³⁾ Here the words even and odd can be interchanged.

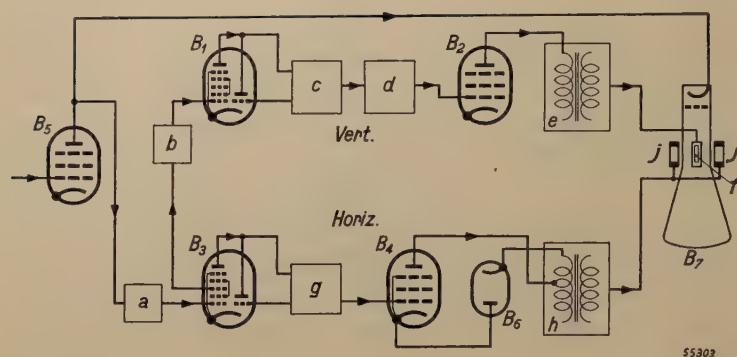


Fig. 2. Block diagram of the synchronisation and deflection apparatus. B_5 = output pentode of the video receiver, B_7 = cathode-ray tube with deflection coils f and j . For the horizontal deflection there is a driver stage (triode of B_3 and network g) and an output stage (pentode B_4 , efficiency diode B_6 and transformer h), and for the vertical deflection likewise a driver stage (triode of B_1 and network c) and an output stage (compensating network d , pentode B_2 and transformer e). a is a source of negative grid bias, b is a network for separating the synchronising signals.

In this diagram the output valve (B_5) of the video receiver has been included. With our circuit the control grid of this valve receives a signal of the form represented in fig. 1. (To bring this about either for positive or for negative modulation the stages preceding B_5 have to be arranged differently for these two methods of modulation.)

The output signal from B_5 , the polarity of which is opposed to that of the input signal (fig. 1), directly controls the cathode-ray tube and thus causes variation in brightness on the screen in accordance with the picture being transmitted.

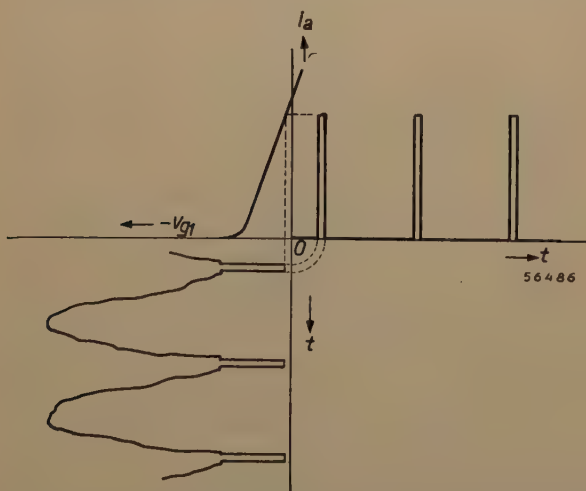


Fig. 3. The video signal is applied to the biased control grid of an amplifying valve in such a way that only part of the amplitude of the synchronising signals initiates anode current (i_a); the other part falls in the cut-off region. v_{G1} = control-grid voltage.

But at the same time this output signal from B_5 is applied to the control grid of an amplifying valve which has a bias so chosen that the black level is clipped off. With the given polarity of the video signal

supplied by B_5 the picture signal makes the grid still more negative (fig. 3). In this manner the picture signal is suppressed. The synchronising signals on the other hand form pulses which cause anode current surges.

This is how the synchronising signals are separated from the video signal. However, they still consist of a mixture of synchronising signals for the two directions of deflection and they have to be separated so that each one of them can act upon the oscillator for which it is destined.

The last-mentioned separation has most commonly been brought about⁵⁾ by feeding the combined synchronising signal (i.e. the output voltage of the

valve in which the picture signal is clipped off) to two series-circuits consisting of a resistor and a capacitor $R'-C'$ and $R''-C''$ (fig. 4). With a suitable choice of the time constants $R'C'$ and $R''C''$ ($R'C'$ smaller than the width of the line-synchronising pulses, thus $R'C'$ less than $0.1 T$, and $R''C'' \approx T$) voltages of the form sketched in figs 5b and c appear across the resistor R' and the capacitor C'' . This is what takes place with the synchronising signals according to the British and French standards (fig. 5a). The fact that the polarity is as indicated in fig. 5a follows from fig. 3.

The voltage across R' has peaks of periodicity T (and during a signal for vertical synchronisation peaks of periodicity $\frac{1}{2} T$) which are well suited for line synchronisation. We are still applying this method, as will be seen farther on.

Owing to the choice of $R''C''$ the voltage $v_{C''}$ across C'' (fig. 5c) shows only insignificant variations in the line-synchronisation pulses, but with the wider pulses of the vertical synchronisation this voltage can vary to a larger extent. When it passes a certain threshold value it is able to initiate in a valve an anode current which causes the light spot to travel up the screen from bottom to top.

However, the moment at which $v_{C''}$ passes the threshold value is not sharply defined, for two reasons. In the first place the value of $v_{C''}$ at which the vertical-synchronising signal begins to operate (fig. 5) is not always the same, this initial value being the remainder of the voltage which the preceding line-synchronising pulses have produced in C'' , whilst the value of this remainder depends upon

⁵⁾ Cf. the article quoted in footnote ²⁾, figs 9 and 10.

the time that has elapsed between the last line-synchronising pulse and t_0 . This period of time, in the case of interlaced scanning, is alternately equal to $\frac{1}{2}T$ and to T (cf. figs 1b and c). In the first

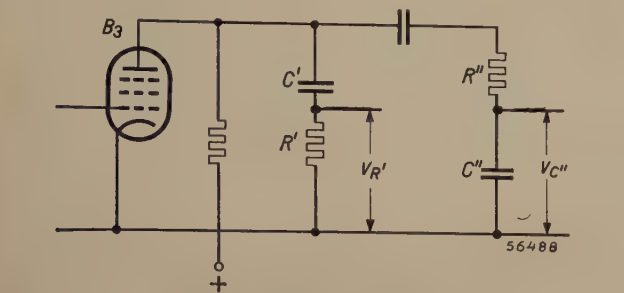


Fig. 4. B_3 = amplifying valve to which the video signal is applied (cf. fig. 3). The two kinds of synchronising signals present in the output voltage are separated by the networks $C'-R'$ and $C''-R''$ with different time constants: $C'R' < 0.1 T$, $C''R'' \approx T$. The horizontal synchronisation is brought about by the voltage $v_{R'}$ across R' ; the vertical synchronisation, according to the old method, is brought about by the voltage $v_{C''}$ across C'' .

case $v_{C''}$ has a certain start and thus the synchronisation is brought about slightly earlier than the synchronisation of the previous or the following frame. The result is that the lines of the even frames do not come to lie exactly half-way between those of the odd frames but have a tendency to "pair" (fig. 6). Obviously this detracts from the fineness of the raster.

This cause of pairing can be eliminated by having a series of so-called equalizing pulses preceding each vertical-synchronising signal, so that the varying duration of the interval mentioned above no longer has any effect. American transmitters employ such equalizing pulses. However, there are other causes of "pairing" which are not eliminated by this means, as we shall presently see.

The second cause of the vertical synchronisation not being sharply defined lies in the fact that the threshold value that $v_{C''}$ has to exceed shows fluctuations which cannot be entirely avoided. In particular, when the threshold voltage has a ripple

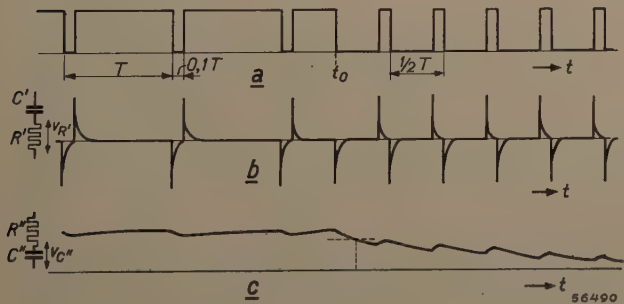


Fig. 5. Voltages in the circuit according to fig. 4. a) Output voltage of the valve B_3 (some line-synchronising pulses followed by a signal for vertical synchronisation); b) the voltage $v_{R'}$; c) the voltage $v_{C''}$.

of the line frequency — and such a ripple may easily arise, for instance via the common supply — this also leads to undesirable pairing of the lines.

Both causes are in fact to be traced to one origin: the gradual rise of the voltage $v_{C''}$. If it were possible to derive from the signal for the vertical synchronisation a pulse with a steep front, such as is shown for instance by the line synchronising pulses illustrated in fig. 5b, then there would

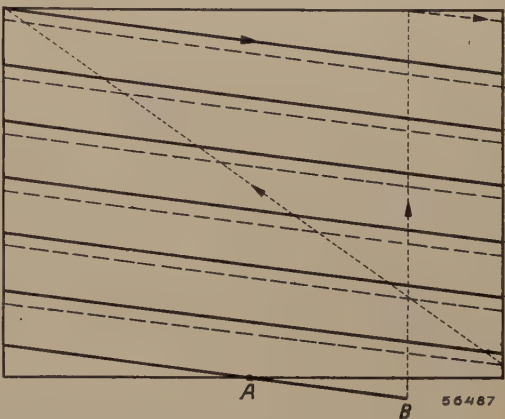


Fig. 6. Pairing of the lines of a television picture arises owing to the flyback not taking place at A but for instance somewhat later, at B. Odd lines are fully drawn, even lines are broken (see footnote 3)), flyback (from bottom to top) dotted lines; flyback times are assumed to be infinitely short.

be none of these troubles. The manner in which the vertical synchronisation can be brought about by means of a steep front will appear from what follows.

Vertical synchronisation with steep front

The method of vertical synchronisation that we are now applying is based upon the following.

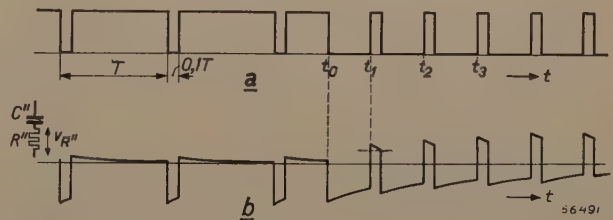


Fig. 7. a) The same synchronising signals as in fig. 5a applied to a circuit $C''-R''$ with $C''R'' \approx T$. Instead of the voltage across C'' , for the vertical synchronisation use is made of the voltage $v_{R''}$ across R'' illustrated under b. The vertical synchronisation is brought about by a positive pulse with steep front at $t = t_1$.

The synchronising signals (fig. 7a) are again conducted to an $R-C$ circuit with a time constant $\approx T$. Instead of taking the voltage across the capacitor we now take that across the resistor, as is done for the horizontal synchronisation. This voltage

has the form represented in fig. 7b. As will be seen, at $t = t_1$ there is a pulse with a steep front. The instant t_1 follows t_0 (at which the signal for the vertical synchronisation begins) after a fixed interval $0.4 T$, which is governed by the transmitter. The pulse at t_1 is therefore excellently suited for vertical synchronisation. Further details are described below, where we shall at the same time have an opportunity to go into some details of the horizontal synchronisation.

Practical execution

The circuit is represented in fig. 8. For the suppression of the picture signal, in the manner depicted in fig. 3, use is made of the heptode part of the heptode-triode B_3 (fig. 2). The synchronising signals thereby occur on the two electrodes serving as output of the heptode, viz. the anode and third grid. The lines are synchronised via the anode and the frames via the third grid.

result, each line-synchronising pulse develops a voltage peak in the positive sense on the grid of the triode and thus initiates current through this valve just at the right instant. This keeps the line-frequency oscillator in the right phase. (Actually there is no resistor R_7 , but there is an equivalent resistor R_7' across the other coil of the transformer, which resistor also performs the function of damping the oscillator circuit formed by the transformer with its self-capacitance.)

The signal for the vertical synchronisation brings about a series of peaks with an interval of only $1/2 T$ on the triode grid. The "interposed" pulses however are ineffective, because the voltage across the capacitor C_3' (fig. 8) is then of such a high value as to keep the valve cut off in spite of the peak in the positive direction.

As already stated, the third grid of the heptode system of B_3 (fig. 8) acts as second output electrode. It is particularly suitable for this function because it is screened from the anode by the fourth grid,

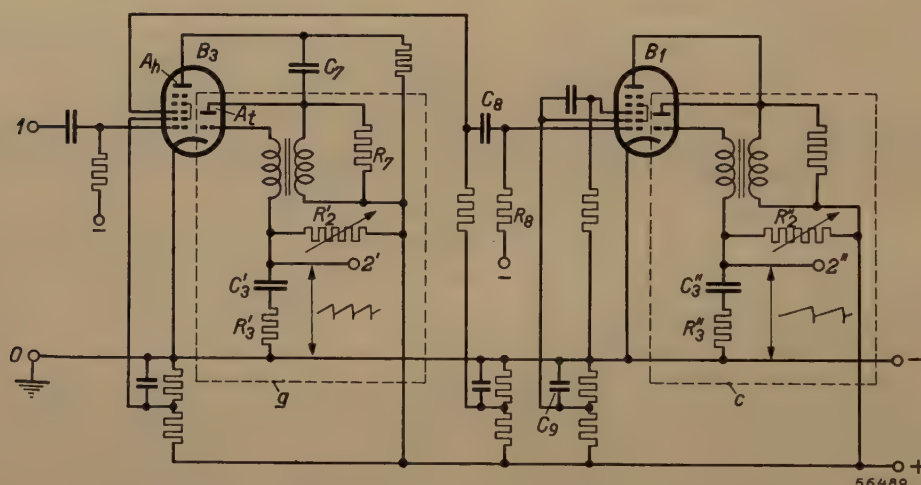


Fig. 8. Complete synchronisation circuit (including the driver stages). 0-1 = input for the video signal, B_3 and B_1 = heptode-triodes ECH 21, g = blocking oscillator for the horizontal deflection (output terminal 2'), c = ditto for the vertical deflection (output terminal 2''). R_7 = damping resistor. The circuit C_7 - R_7 corresponds to C' - R' (fig. 5b), the circuit C_8 - R_8 corresponding to C'' - R'' (fig. 7b). C_9 = smoothing capacitor of small value.

Let us first consider the line-synchronisation, which needs little explanation. The anode A_h of the heptode is connected to a network C_7 - R_7 which corresponds to C' - R' of fig. 4 and carries the voltage pulses from A_h to the anode A_t of the triode. Thus the voltages at A_h and at A_t follow the form indicated in figs. 5a and 5b respectively. The triode forms part of the saw-tooth oscillator for the line frequency.

The transformer bringing about the coupling between the grid circuit and the anode circuit of the triode is connected in such a way that a voltage drop at A_t causes a voltage rise at the grid. As a

which is made in the form of a screen grid, and thus is affected very little by the high voltage peaks (with the line frequency) occurring at the anode. It is, however, essential that the mean voltage on the third grid should be fairly low, such with a view to the proper distribution of the cathode current between the various grids and the anode; the third grid is therefore connected to a tapping on the supply source, as may be seen in fig. 8.

In series with the third grid is a resistor across which voltage pulses occur having the form of the synchronising signals. A coupling element C_8 - R_8 transmits these pulses to the control grid of the

heptode system of the valve B_1 . This coupling element is the aforementioned R - C circuit which transforms the synchronisation signals (fig. 7a) into the form represented in fig. 7b. The sign of the voltage across R_s and the value of the bias on the control grid are such that only positive peaks of the pulses occur in the grid base. Only at these peaks — in fact, as will appear presently, only at the first of these peaks — can anode current flow through the heptode (B_1). The anode of this heptode is coupled to the anode of the triode system contained in the same valve and generating the saw-tooth voltage of the frame-frequency. The coupling

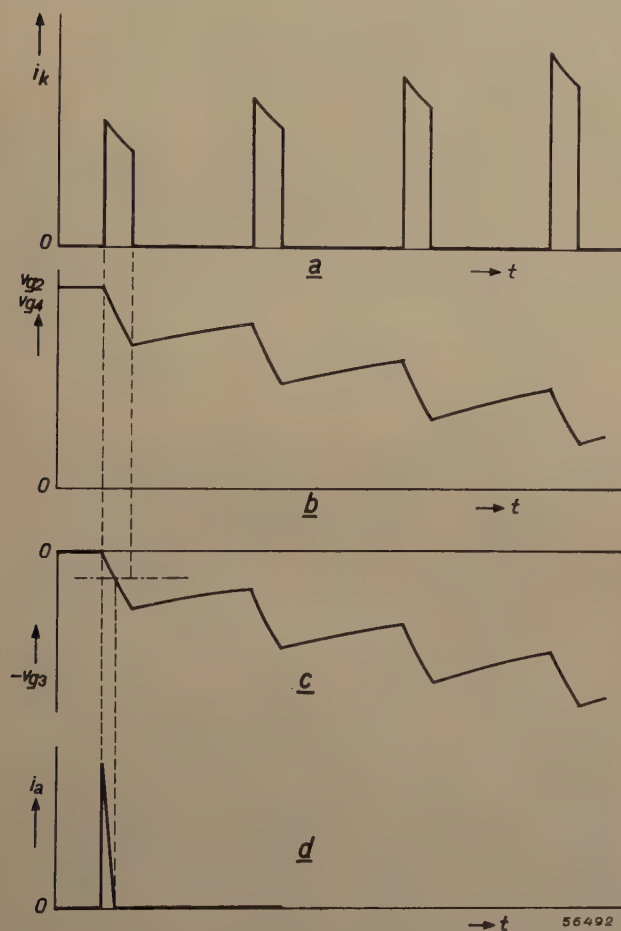


Fig. 9. The wave-form as function of t , during a vertical synchronising signal, of
a) the cathode current i_k in the heptode system of B_1 (fig. 8),
b) the voltage $v_{g2} = v_{g4}$ on the two screen grids,
c) the voltage v_{g3} on the third grid,
d) the anode current i_a .
After the first pulse in v_{g3} anode current surges no longer occur until the next signal for vertical synchronisation comes through.

may consist of a connection between the two anodes. The voltage on this coupling shows a polarity which is the reverse of that in fig. 7b., but the coupling transformer again ensures that the synchronising pulse reaching the grid of the triode has a positive sign.

Thanks to the steep front of the pulses on R_s there is no fear of any of the difficulties arising which occur in the case of a gradually rising grid voltage (fig. 5c).

In one respect, however, a small precaution has to be taken in this system. The triode grid of B_1 receives not only a positive pulse at the instant t_1 (fig. 7) but also a number of successive pulses at t_2, t_3 , and so on, and furthermore, after the signal for the vertical synchronisation has stopped, line-synchronising pulses following one upon the other at an interval of time T (fig. 1b or 1c). These latter pulses on the triode grid of B_1 are undesirable.

At the instants that these line-synchronising pulses occur the grid current discharging the capacitor C_3'' and starting to flow at t_1 has dropped almost to zero; the instant at which this current becomes zero is subject somewhat to the effect of the pulses previously referred to. Now in itself this would be no objection if the pulses always had the same time interval with respect to t_1 , but this is not the case, as may be seen from figs 1b and c. The line-synchronising pulse A lies $\frac{1}{2}T$ closer to t_1 than the corresponding pulse B . In other words, with the even frames the capacitor C_3'' would begin to charge itself again at a moment slightly different from that in the case of the odd frame. This would mean again a certain tendency towards pairing.

This risk is avoided by so arranging the circuit that the first current surge through the heptode (B_1) itself causes the anode circuit to be blocked for a time, so that further pulses do not occur. By the time that the next signal for vertical synchronisation comes through, the charge bringing about the negative grid bias has leaked away sufficiently to allow of the valve functioning again normally.

This blocking of the anode circuit takes place in the following way (see fig. 8). The two screen grids of the heptode (B_1) are fed via a common series resistor and are connected to the cathode via a smoothing capacitor (C_6) of small value. As soon as current begins to flow through the heptode the voltage on the screen grids drops. This voltage drop is transmitted via a coupling capacitor to the third grid, which was previously at zero potential but then becomes negative. With each successive cathode current surge (fig. 9a) the voltage on the three grids again drops (figs 9b and c). Already at the first voltage drop the voltage on the third grid falls below the cut-off limit and the anode current is kept at zero (fig. 9d). Thus only one anode current surge takes place, and that is the one that brings about the vertical synchronisation.

Concluding remarks

The synchronisation system described can be used for all present-day television standards and is

entirely free of pairing of the picture lines. It is employed in the Philips projection-television receiver but is of course equally suitable for "direct-vision" receivers.

The form of execution with two heptode-triode valves (type ECH 21) described here has the advantage of requiring the smallest number of valves,

but it is not the only possibility. For instance, with a few small alterations, the heptode systems could each be replaced by a pentode, and the two triode systems could be combined into one double triode.

A photograph of the receiver built on these lines was given in article IV (fig. 2).

ABSTRACTS OF RECENT SCIENTIFIC PUBLICATIONS OF THE N.V. PHILIPS' GLOEILAMPENFABRIEKEN

Reprints of these papers not marked with an asterisk can be obtained free of charge upon application to the Administration of the Research Laboratory, Kastanjelaan, Eindhoven, Netherlands.

1804: J. van der Vliet: Investigations on sterols, IV. The configuration of the junction between rings C and D in cholesterol. (Res. Trav. chim. Pays Bas **67**, 343-348, 1948, No. 6.)

The ketone $C_{18}H_{32}O$, obtained by the oxidation of vitamin- D_3 and which still contains the rings C and D of the original sterol, appears to be readily converted into an isomer and the same holds for its semicarbazone. This isomerisation is to be explained by the conversion of the trans-hydrindane into the cis-hydrindane configuration. From this it is concluded that the junction between the rings C and D in vitamin- D_3 , 7-dehydrocholesterol and cholesterol very probably has the trans-configuration.

1805: A. H. W. Aten Jr. and J. v. Dreven: A simple apparatus for the measurement of diffusion rates (Trans. Faraday Soc. **44**, 202-204, 1948, No. 4.)

The method proposed by the writers consists in filling the pores of a porous disc with the solvent, after which the disc is immersed e.g. for two hours in a beaker containing the solution for measurement which is kept at a constant temperature.

After this the contents of the disc are sucked into a beaker and the liquid in the beaker is analysed.

1806: P. C. van der Willigen. Warm-scheuren in lasrupsen en blauwbrosheid (Lastechniek **14**, 95-102, 1948, No. 8). (Hot-cracking in welds and blue-brittleness; in Dutch.)

The author discusses some aspects of hot-cracking in welds, the most important of which are:

1) Differences in sensitivity for hot-cracking are often accompanied by differences in blue-brittleness (measured by notch impact tests).

2) The blue-brittleness of the material deposited is to be ascribed to the joint action of impurities, the differences between various types of electrodes and especially to the N- and O-content.

3) A characteristic difference in the various types of welding electrodes is the H-content immediately after welding. This is presumably also a cause of the difference in sensitivity for hot-cracking.

1807: H. C. Hamaker: Toevals-frequenties, een hulpmiddel bij de constructie van kunstmatige steekproeven van grote omvang (Statistica **2**, 129-137, 1948, No. 4). (Random sampling frequencies, a short-cut technique for the artificial constructions of large-size random samples; in Dutch.)

In this article a short-cut technique is described to arrive at artificial random samples of, say, 500 or 1000 scores, making use of previous records of the frequencies of two-digit random sampling numbers.

1808*: H. J. Vink: Het geleidingsmechanisme van de oxydekathode (Thesis, Leiden 1948, 170 pp., 63 fig. 5 tables). (The conduction mechanism of the oxide cathode; in Dutch.)

The resistance of a normal BaSr oxide coating is studied as a function of the temperature and at various degrees of formation. The $\log R \cdot T^{-1}$ characteristic is proved to consist of different parts, each part corresponding to one of the different results mentioned in the literature on the subject. It is impossible to explain the results on the basis of modern theory of electronic and ionic conduction of solids alone. Therefore a new theory is given, taking into account the conduction through the electron gas present between the emitting grains

of the porous oxide coating. Starting from reasonable assumptions as to the electron emission of separate grains, it is proved to be theoretically possible to calculate a resistance of the same order of magnitude as that experimentally observed; at the same time certain peculiarities of the characteristics may be explained in this manner.

1809: P. W. Haayman en G. W. Oosterhout: Eigenschappen en toepassing van halfgeleiders als weerstandsmateriaal met grote negatieve temperatuur-coëfficiënt (Electrotechniek 26, 342-347, 1948, No. 21). (Properties and application of semi-conductors having a high negative temperature coefficient of the electrical resistance; in Dutch).

In this paper a survey is given of the properties of semi-conductors and of their most obvious applications in electric circuits, such as protection against high currents, compensation of a high positive temperature coefficient, resistance thermometer, bolometer, wattmeter, artificial horizon, voltage stabilizer and adjustable resistance without moving contact.

R 89: B. D. H. Tellegen: The synthesis of passive, resistanceless four-poles that may violate the reciprocity relation (Philips Res. Rep. 3, 321-337, 1948, No. 5).

The most general, passive, resistanceless four-poles of a certain order that may violate the reciprocity relation are investigated. They can be realized by means of inductances, capacitances, ideal transformers and ideal "gyrators" (cf. R 73). Of every order there are two types of four-pole, which can be transformed one into the other by connecting an ideal gyrator to any of their terminal pairs. The necessary and sufficient conditions of realizability are derived.

R 90: W. Elenbaas: Dissipation of heat by free

convection, Part I (Philips Res. Rep. 3, 338-360, 1948, No. 5).

This article is identical to that published in "De Ingenieur" (see these abstracts, No. 1773).

R 91: A. van Weel: A new principle for transceivers (Philips Res. Rep. 3, 361-370, 1948, No. 5).

It is shown that the self-oscillating triode mixing stages described in a former article (see these abstracts, No. R 80) offer distinct advantages for transceiver circuits, the most important of which is the possibility of switching from transmitting to receiving, and vice versa, fully electrically without any mechanical switching in the antenna circuit. As a consequence, switching in an ultrasonic frequency can be used, making it possible to establish a two-way communication. A system is described for stabilizing the frequency of both the transmitting oscillator and the local oscillator for reception with the aid of one cavity resonator.

R 92: J. H. van Santen and G. H. Jonker: The temperature dependency of the index of refraction of heteropolar solids (Philips Res. Rep. 3, 371-377, 1948, No. 5).

While the electronic polarizability of molecules does not vary much with temperature it is found that the electronic polarizability of heteropolar lattices shows a pronounced dependency on temperature. A tentative explanation is suggested based upon the assumption that the electronic polarizability of heteropolar lattices is mainly of an electron-transfer type.

R 93: J. F. Klinkhamer: Empirical determination of wave-filter transfer functions with specified properties, Part II (Philips Res. Rep. 3, 378-400, 1948, No. 5).

Continuation of a previous article (see these abstracts, No. R 72, where the contents of the present paper are indicated).

Erratum

The code number of the article AN IMPROVED X-RAY DIFFRACTION CAMERA published in Philips Techn. Rev. Vol. 10, No. 6, 1948, p. 157, should read
548.73:621.386.1:778.332 instead of 548.73:621.386.1:788.332

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